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THE MINERALS OF CASAPALCA, PERU[1]

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Introduction

Since the days of the Spanish conquerors the mineral wealth of the Andes, and the even more fabulous reports of it, have made the name of Peru synonymous with untold riches and have attracted mining ventures, first on the part of daring colonial prospectors and later of substantial modern companies, into the rugged peaks and high treeless plateaus of the cordillera. The mineralogist, however greatly intrigued by the glamor of romance, finds much of a purely scientific nature to claim his interest.

Viewing Central Peru as a whole, one is impressed by the manner in which the mineralogy of each particular district, while having its individual peculiarities, accords with the general characteristics of the region. There is, throughout, a general abundance of arsenic and antimony, richness in silver and, in spite of the tales of Inca treasure, poverty in gold. Thus, the mines of Morococha are famous for their large and brilliant crystals of tetrahedrite and those of Cerro de Pasco for their famatinite and enargite, particularly the rare variety luzonite.

At Casapalca, enargite is unknown, and while tetrahedrite of the silver-bearing variety is abundant as are a number of more common minerals, beautifully crystallized, the most spectacular specimens are those of bournonite.

Location

The Central Railway of Peru climbs nearly 16,000 feet in the course of an eight-hour journey from the Pacific coast at Callao to the continental divide. Just below the summit, deep in the valley of the Rimac River, are the station and camp of Casapalca at an elevation of about 13,700 feet. The mine workings are in the mountains to the east which rise more than 3,000 feet higher.

[1] The writer is indebted to Professors L. C. Graton and D. H. McLaughlin for much assistance during geological work on the ore deposits and to Mr. L. W. Lewis for cooperation in the mineralogical study. For permission to publish the present paper thanks are due to the officers of the Cerro de Pasco Copper Corporation.

General Geology

The river has carved its valley through a thick series of redbeds—sandstone and shale—affording ideal exposures of the sedimentary series and of the andesitic flows which overly it. These formations, which are presumed to be of Tertiary age,[2] are folded along the northwest-trending axes of Andean structure and are intruded by stocks and sills of albite-diorite porphyry.

Veins. The veins, which cut both the redbeds and the extrusives, are of the type deposited at intermediate to shallow depths. The gangue consists of quartz, calcite and rhodochrosite; the metallic minerals are chiefly pyrite, sphalerite, galena and tetrahedrite. To the geologist, an interesting feature of the vein system is the definite zonal arrangement of mineralization, both laterally and vertically from what is believed to be the center of deposition. In those portions of the veins which were supposedly formed under more intense conditions of heat and pressure, the sulphides are coarse-grained, chalcopyrite is common, tetrahedrite occurs sparingly and carbonates are nearly absent. Away from the center, tetrahedrite and carbonates become more abundant, and chalcopyrite is very rare. With the coolest phases of mineralization, botryoidal carbonates and stibnite begin to appear, and in the outlying mines of the district, barite becomes important.

Another interesting geological feature is the change in proportion of minerals with different types of wall-rock. The redbeds contain some calcite and where they form the vein-walls, the gangue in general abounds in carbonates, while in the porphyry quartz is the principal non-metallic mineral.

Mineralogy

The veins are in many places open in texture and contain large crystal-lined vugs. During the summer of 1923 a great vug was opened up which was lined with crystals of quartz, sphalerite, calcite and bournonite, and from it many beautiful specimens were taken.

Throughout the Casapalca district the minerals both in the vugs and in the massive ore show a definite order of deposition. Polished sections of the massive vein matter studied under the microscope show this to be as follows: quartz, pyrite, sphalerite, galena, tetrahedrite, and bournonite. Veins of quartz and calcite appear at a number of points throughout the sequence and pyrite also appears at various stages.

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[2] McLaughlin, D. H.; *Bull. Geol. Soc. Am.* 35, pp. 591-632 (1924).

In the vugs the order is similar. Adjoining the massive ore which contains quartz and pyrite the vugs are first lined with sphalerite crystals some of which are a centimeter or more in diameter. Upon the sphalerite is bournonite and around the latter crystals, and frequently upon them, quartz prisms attached by their bases form radiating groups. Perched upon all of these minerals are tufts of calcite scalenohedra. Galena and tetrahedrite are usually not well crystallized; occasionally galena crystals are intergrown with the bournonite as though the two minerals had started crystallizing from different centers and interfered with each other during growth. Tetrahedrite is commonly pitted as though by etching and is sometimes covered by a film of chalcopyrite. The pyrite, where it has had an opportunity to crystallize in open vugs, is usually in quite perfect pyritohedrons. Where replacing wall-rock it is usually in cubes, while octahedrons of pyrite are unknown at this locality.

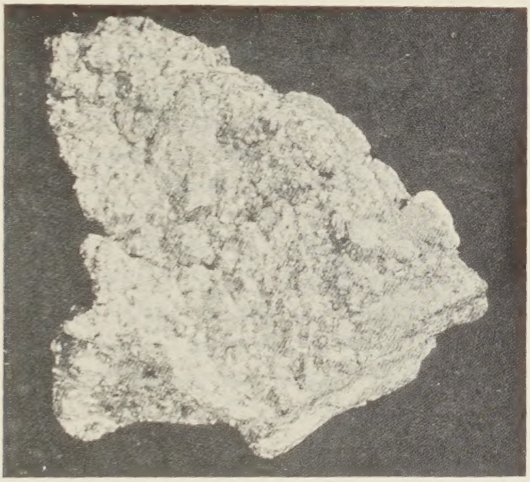

Fig. 1. Bournonite Crystals on Quartz and Sphalerite. (Photo. by E. B. Dane, Jr.)

The bournonite crystals have been described by Gordon.[3]

[3] Gordon, Samuel G.; Crystallographic Notes on Six Minerals from Peru and Bolivia: *Proc. Acad. Nat. Sci. Phila.*, vol. 76, 336, (1924).

Measurements made by Mr. L. W. Lewis of Harvard University showed the same forms as those which Gordon described, namely: *a* (100), *c* (001), *m* (110), *o* (101), *n* (001) and *u* (112). The crystals are splendent and some are nearly a centimeter in diameter. Usually the basal and prism forms dominate.

In portions of the veins, pink cleavable rhodochrosite is abundant; in others the carbonates take the form of manganiferous calcite and dolomite. Rhodonite occurs sparingly in grains up to 1 cm. in diameter in veins with quartz.

Within the main veins a type of vein matter of a late generation consisting of botryoidal carbonates, with quartz-lined vugs, carries realgar in grains a centimeter or more in width. The contrast of this red mineral against white quartz gives some of the specimens a strikingly beautiful appearance. In the same type of vein matter are blades of stibnite, sometimes in radiating aggregates up to two centimeters in length. Stibnite occurs also toward the edges of the strongly mineralized zone in masses of tiny hair-like needles occupying vug-spaces.

One very interesting outlying mine, the Corina, apparently on a continuation of the main vein system, shows mineralization of a somewhat different sort. The gangue, subordinate in amount, consists of quartz and calcite; the reddish porphyry wall-rock is cut by a network of stringers which consist of sphalerite grains surrounded by a felt-like mass of boulangerite. The ore, examined microscopically, shows tiny crystals of arsenopyrite replacing quartz of the gangue. Sphalerite in part corrodes the arsenopyrite and contains needles of boulangerite.

Near the surface the veins show the usual alteration products; limonite, psilomelane, sparing amounts of malachite, azurite, chrysocolla and smithsonite. In the mine workings descending waters have deposited kaolin, allophane, and the sulphates gypsum, chalcanthite and melanterite. The primary sulphides are slightly enriched near the surface by chalcocite and covellite.

Apart from the veins, intrusives in the district have developed alteration minerals in the rocks. A little tourmaline is developed in the shale around bodies of andesite, and in other places veinlets of epidote and specularite appear. To the west of Casapalca, at the head of Tablachaca Quebrada, contact minerals in limestone, including garnet and axinite, have been found.

CONTRIBUTIONS FROM THE DEPARTMENT OF MINERALOGY AND PETROGRAPHY, HARVARD UNIVERSITY.

AEGIRITE FROM LIBBY, MONTANA

ROY W. GORANSON.

The aegirite described in this paper was collected in the Rainy Creek area, near Libby, Montana, by E. S. Larsen, who kindly furnished the description of the field occurrence.

The Rainy Creek intrusive stock cuts the Precambrian Belt rocks and is about three miles across. The chief rock of the stock is a pyroxenite with about ten per cent of apatite. Locally this pyroxenite carries considerable biotite. The pyroxenite is cut by bodies of syenite and nephelite syenite. It is also cut by veins of quartz that carry some chalcopyrite and vanadiferous aegirite[1] near their border. The pyroxenite is uralitized for a few inches on both sides of these veins.

The aegirite described in this paper was collected from a dike of coarse syenite pegmatite, about twenty feet wide, near the contact of the Belt rocks and the pyroxenite in the northern part of the stock. The syenite is poorly exposed but a prospect tunnel follows the dike for seventy-five feet. The syenite is traversed by numerous zones of fracture and a layer of aegirite needles, mostly less than a millimeter thick, lines these fractures. The aegirite also extends for some distance from the fractures as well-formed needles penetrating and replacing the perthite. The unaltered syenite contains little or no aegirite.

The hand specimens consist of microcline and aegirite. The microcline forms tabular plates. It is coarse grained and some of the plates measure seven centimeters along the *c*-crystal axis and about one and a half centimeters along the *b*-axis. The aegirite occurs as needles, usually about a centimeter or less in length and less than a millimeter thick, which interlace to form a mat along cracks and cleavages in the microcline. The aegirite works into and replaces the microcline from these openings, leaving in places a penetrating net of aegirite needles in a microcline matrix and fingering out in the massive part of the microcline grains. In some places the aegirite works out on all sides as a radiating cluster resembling a spherulite in general appearance.

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[1] Larsen, E. S. and Hunt, W. F.: Two vanadiferous aegirites from Libby Montana. *Am. Jour. Sc.*, **XXXVI**, 289–296, (1913).

There is, then, a time break between the formation of the microcline and the formation of the aegirite and a change in the composition of the solutions. The inference is that the aegirite represents a replacement formed by later hydrothermal solutions.

Two specimens came into the writer's hands which were replicas of the Libby aegirite in that they showed the same type of replacement. One came from Ice River, B. C., and the other from the Kola Peninsula, Finland.

Physical and optical properties. The aegirite is leaf green in color and powders into tiny fibers due to a very good prismatic cleavage. It fuses in the Bunsen flame to a reddish brown bead and has a fusibility of 2.

The specific gravity as determined is 3.52; as calculated from the Gladstone and Dale rule is 3.57.

The indices with a possible error of $\pm .003$, are $\alpha = 1.742$, $\beta = 1.768$, $\gamma = 1.787$; 2V, calculated, is 81°; the dispersion is moderate, $\rho > \nu$; $\beta = b$, $\alpha \wedge c \leqq 2^\circ$. The pleochroism is faint, X = olive green, Y = lighter olive green, Z = yellowish green.

Chemical analysis. A sample of material shown by microscopic examination to be homogeneous except for a few small dark stains between cleavage cracks, which may be of manganese, was analyzed by Helen E. Vassar. The results of the analysis are shown in column 1 and the analysis of the vanadiferous aegirite which also occurs in a vein in Rainy Creek, is shown in column 2. The optical properties of the two aegirites are much alike and the chemical differences are not great. The aegirite described in this paper caries more SiO_2 and TiO_2 and lacks V_2O_3.

Analysis and Ratios of Aeigrite

Constituents	1 Per cent	1a Mol. proportions	2 Per cent
SiO_2	53.11	885	51.91
Al_2O_3	1.25	12	0.38
Fe_2O_3	21.73	136	21.79
FeO	1.57	22	1.48
MgO	3.97	98	3.08
CaO	5.15	92	5.53
Na_2O	10.22	165	10.46
K_2O	.18	2	0.22
H_2O (total)	.27		0.06
TiO_2	2.57	32	0.91
MnO	.44	6	0.58
V_2O_3	none		3.98
S	none		0.13
	100.46		100.51

A recalculation of the analysis gives (1) the following molecular composition.

		Per cent
Acmite	$Na_2O.Fe_2O_3.4SiO_2$	62.82
Jadeite	$Na_2O.Al_2O_3.4SiO_2$	4.85
Wollastonite	$CaSiO_3$	10.67
Enstatite	$MgSiO_3$	9.80
Hypersthene	$(Fe,Mn)SiO_3$	3.26
$(Na,K)_2O.\ SiO_2$		2.87
TiO_2		2.57
SiO_2		3.36
H_2O		.27
		100.47

On the basis of this recalculation the mineral is made up chiefly of acmite and diopside with some jadeite.

Some of the material contains minute patterns which have the appearance and structure of sagenite when examined under a high power objective. This pattern looks like a breakdown, representing a separation of rutile similar to that sometimes found in altered biotite. The TiO_2 may then represent one component of a solid solution which is unstable not far below its temperature of formation. The action of later hydrothermal solutions, perhaps acting in a manner analogous to a catalytic agent, may have brought about the separation.

LÖLLINGITE FROM FRANKLIN, NEW JERSEY

L. H. Bauer, *Franklin, New Jersey,*
AND
H. Berman, *Harvard University.*

Measureable crystals of the mineral löllingite have been so rarely found that a new occurrence seems worthy of record. The observations here presented are based on specimens found during 1926 in the orebody of the mine at Franklin in a drift of the 750 foot level north. The crystals are sparsely embedded in a white limestone of medium grain together with grains of a gray pyroxene and occasional dots of franklinite. The löllingite crystals are complete individuals, brilliant tin-white in color, ranging in size from tiniest specks to a diameter of 3 mm. They break freely and cleanly from the matrix and the brilliance of their lustre marked them at once as suitable for crystallographic study. Several crystals were measured by the junior author and gave excellent readings and very accordant angles as recorded in table 1 below.

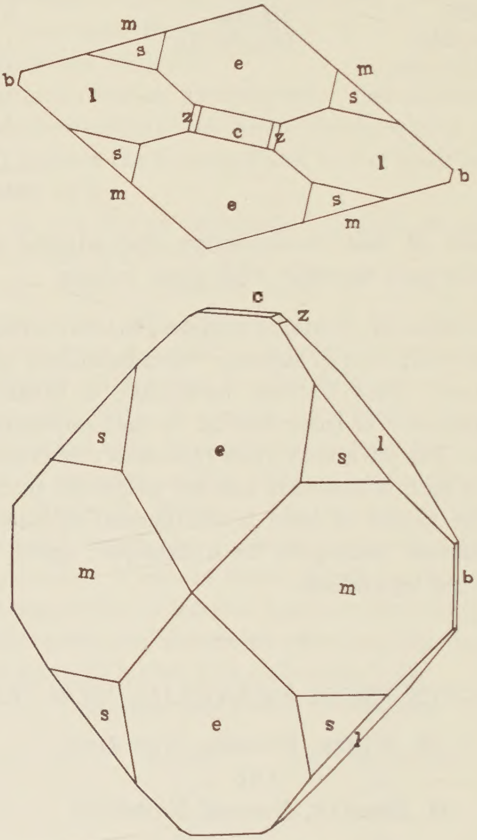

Fig. 1. Löllingite, Franklin, N. J.

These angles however differed so markedly from those previously recorded for löllingite that further measurements on the same and on other crystals were made by Professor Palache. These exactly confirmed Berman's results and served to emphasize the fine quality and extreme accordance of the angular values which these crystals present.

The habit of the crystals is variable; a few are prismatic parallel to the *a* axis, the brachydome giving almost a square cross-section, with small faces of prism and macrodome on the ends; some are equant with pseudocubic development, the isometric appearance heightened by numerous rounded surfaces between the brilliant faces of the three dominant forms. But the greater number are as shown in the figure, slightly flattened normal to the *a* axis and almost identical in development with the marcasite from Schemnitz shown in Dana, System, page 95, figure 2; or with only the forms *m*, *l*, and *e*, and striated parallel to the intersection edges of *m* and *e*.

TABLE 1. ANGLES OF LÖLLINGITE.

FORM	SYMBOL	MEASURED ANGLES		NO. OF FACES	QUAL.	CALCULATED ANGLES	
		φ	ρ			φ	ρ
c	(001)	0°00′	0°00′	1	poor	0°00′	0°00′
b	(010)	"	90 00	2	"	"	90 00
m	(110)	61 26 ±2	"	8	excell.	61 27	"
l	(011)	0 00	48 29 ±1	4	"	0 00	48 30
s	(012)	"	29 20 ±6	2	poor	"	29 28
e	(101)	90 00	64 17½ ±1½	4	excell.	90 00	64 18
r	(111)	61 29 ±3	67 07 ±1	3	fair	61 27	67 05

The dominant forms on the two measured crystals are *m*, *l*, and *e*. Their position angles as shown above scarcely vary as much as two minutes from crystal to crystal, a most unusual degree of accordance for crystals of any substance. The pyramid, *r*, is less constant in its quality and the other forms are negligible in development and quality. The elements were calculated from 19 faces of the forms noted, particular weight being given the prism faces in averaging the results. These elements, from which were calculated the angles given in table 1, are given below together with those hitherto accepted for löllingite and those of other members of the marcasite group.

TABLE 2. CRYSTALLOGRAPHIC ELEMENTS

	$a : b : c$	p_0	q_0
Löllingite, Franklin	0.5438 : 1 : 1.130	2.078	1.130
Löllingite, Norway, Brögger	0.6689 : 1 : 1.233	1.843	1.233
Arsenopyrite, Hohenstein, Dana	0.6773 : 1 : 1.188	1.754	1.188
Arsenopyrite, Franklin	0.6702 : 1 : 1.189	1.775	1.189
Marcasite, average, Goldschmidt	0.7580 : 1 : 1.212	1.599	1.212

It is evident from a consideration of table 2 that the marcasite group is not characterized by close accordance of the crystallographic elements of its members. The new values for the Franklin löllingite are very different from the only elements hitherto published, namely those given by Brögger for the löllingite of Norway which are commonly accepted. Reference to Brögger's description of his measured crystals leaves, however, no doubt that they were ill adapted for accurate measurement. The new elements appear to be established. It may be noted that the elements of arsenopyrite are intermediate to those of marcasite and löllingite, as newly established, a relation which seems reasonably to be expected. Since the arsenopyrite elements are subject to wide variation in crystals from different localities, a calculation was made of the elements of the slightly cobaltiferous arsenopyrite from Franklin, an analysis of which was published[1] in 1910 together with new forms found on the crystals. These were of the finest quality. The elements, calculated from measurements of 30 faces of the forms *m*, *l*, *e*, and *s* on 6 crystals are shown in table 2 and agree closely with those used in Dana's System.

In table 3 there is shown for the three minerals under consideration the variation of the angles of three important forms corresponding to the variation of the elements. The figures there given for löllingite crystals from Trotter Mine, Franklin, were made on poor crystals but are of interest because of their agreement with the angles calculated from the elements of the new crystals.

TABLE 3. VARIATION OF ANGLES

	010 to 110 $=\varphi$ of *m*	001 to 011 $=\rho$ of *l*	001 to 101 $=\rho$ of *e*
Löllingite, Franklin	61°27′	48°30′	64°18′
Löllingite, Trotter Mine	60 58	48 39	63 46
Arsenopyrite, Hohenstein, Dana	55 54	49 55	60 19
Arsenopyrite, Franklin	56 10	49 56	60 38
Marcasite, Dana	52 33	50 59	58 10

A chemical analysis of the Franklin löllingite was made by the senior author, using 0.4 grams of carefully selected crystals, with the following result.

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[1] C. Palache. Contributions to the Mineralogy of Franklin Furnace. *Am. Jour. Sci.*, 29, 177 (1910).

	Per Cent	Molecular Ratios	
As	69.80	.933	1.78
S	0.21	.007	
Fe	29.40	.530	1
	99.41		

The slight deficiency of the analysis is due to the presence of calcite in small amount which was not determined. Sulphur is practically absent. There is insufficient arsenic, as shown by the molecular ratios, to yield exactly the 2 : 1 ratio of löllingite. Such a deficiency is common in analyses of this mineral and has generally been accounted for by assuming the presence of varying amounts of the leucopyrite molecule, $Fe_3 As_4$. In this case calculation shows the presence of 14% of leucopyrite.

The authors are very glad to acknowledge the considerable help given by Professor Charles Palache in the preparation of this paper.

THE PREPARATION OF OPTICALLY CLEAR SELENIUM FOR USE IN INDEX MEDIA[1]

L. T. Brownmiller, *Bureau of Standards*

Abstract

In the preparation of selenium-sulphur mixtures for use as index media, one is encountered with the difficulty of obtaining selenium which is optically clear when melted into thin films. Minute particles of another phase are commonly present which interfere with the index determinations. These have been identified as selenium dioxide, and a method is described for the removal of this material by distillation in an atmosphere of carbon dioxide.

Introduction

In the determination of the optical properties of minerals, by the immersion method, materials frequently are encountered the refractive indices of which lie above those of the usual immersion media. For index determinations between values of 2.05 and 2.75 sulphur-selenium mixtures have been recommended.[2]

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[1] Published by permission of the Director of the National Bureau of Standards of the U. S. Department of Commerce. Paper No. 7 of the Portland Cement Association Fellowship at the Bureau of Standards.

[2] Larsen and Merwin; *Am. J. Sci.*, 34, 42, (1912).

These are prepared by mixing carefully weighed portions in accordance with the index-composition curves of Larsen and Merwin, melting to a uniform material and, after cooling, rechecking the index by some standard procedure.

In the immersion method a small amount of the powdered medium is placed on the slide and the material whose index is to be determined is scattered on it. A cover glass is placed upon the mixture and the slide is heated over a small flame until the medium is liquid. It can then be pressed readily into a thin film and the determination made. There is but little danger of change in the index due to volatilization of either the sulphur or selenium.

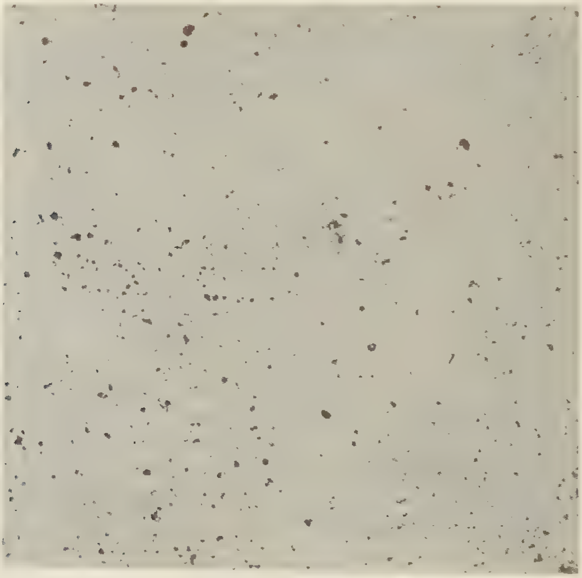

Fig. 1.
Appearance of thin film of commercial "pure" selenium, x 200.

In making such media it was found that the selenium contained some foreign material in amounts which prevented the transmission of sufficient light for standardization; and this impurity made impossible exact determination of the indices. In a thin film of the selenium the impurity appeared under the microscope as black opaque grains as shown in Figure 1. Upon closer examination, many of these grains were identified as aggregates of very small particles; and small individual particles were scattered through the whole field. The present investigation was undertaken therefore to establish a method for the purification of selenium by means of which the opaque particles would be removed.

EXPERIMENTAL METHODS

The methods of purification of selenium described in the literature are concerned mainly with the removal of sulphur and tellurium. The latter may be used to form a series of index media with selenium, the range of which lies above 2.75. Accordingly neither of these two materials is detrimental in selenium to be used for index determinations. But since they are the most difficult common impurities to remove (as reported) due to their similarity to selenium, some of the methods of their separation were applied to the further purification which is necessary to remove the opaque material.

One of these methods depends on the oxidation of the selenium to the dioxide and the subsequent reduction of the dioxide to the element. The selenium was oxidized readily by dissolving it in nitric acid. After filtration, the solution was evaporated to dryness, the dioxide sublimed and dissolved in water. It was then reduced: in one case by sulphur dioxide; in another by hydrazine. There seemed however to be no diminution in the amount of impurity after such treatment.

Purification by distillation was then attempted. The element melts at about 220°C. and boils at about 688°.[3] Distillation was carried out in large glass test-tubes, bent to form an angle of about 120°, and held in such a position that the outlet was slightly inclined. The distilled selenium was collected in a suitable receptacle placed beneath the mouth of the tube. It was found to contain the impurity even after several such distillations.

During the previous operation it was noticed that long needles collected in the test tube near the mouth. These crystals had indices greater than 1.76, possessed a high birefringence, showed parallel extinction, and gave a uniaxial positive interference figure. Accordingly they belonged to the tetragonal or hexagonal systems. Determinations on the selenium dioxide obtained by oxidation showed identical optical properties.

Therefore it was assumed that the impurity in the selenium was selenium dioxide. Distillation was again attempted from tubes constructed similarly to those used before, but suction was applied to the cold end with an attempt to exclude any oxygen. Due to difficulties in sealing the tube, air was constantly being drawn into the selenium vapor and the distilled material had considerable impurity in it. Furthermore, due to the high temperature and the reduced pressure within the tube, it collapsed readily and in that respect the method was not satisfactory.

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[3] Internat. Critical Tables, Vol. 1, 104, 102, (1926).

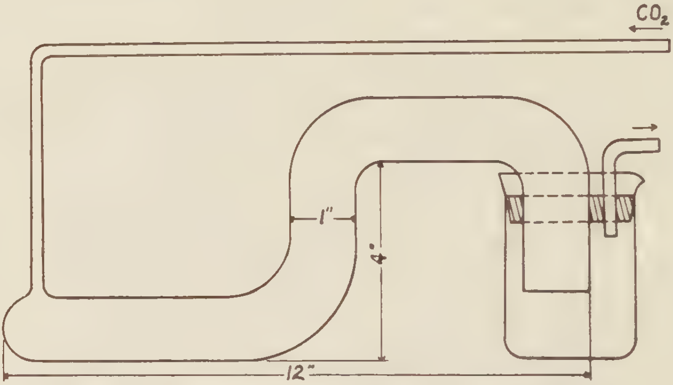

Fig. 2 - Apparatus for Distillation of Selenium

Distillation in an inert gas was suggested. Carbon dioxide seemed most desirable. A tube of heavy glass was constructed, as shown in Figure 2, one inch in diameter and about 12 inches long. The carbon dioxide was passed through the smaller tube directly over the selenium for several minutes before beginning the distillation, and continued throughout the entire operation. The tube was put into a muffle furnace with the beaker for collecting the selenium just outside. Asbestos paper was used to close the furnace and shield the beaker. The charge was comparatively small (about 200 grams) and distillation proceeded rapidly. The temperature of the furnace did not greatly exceed that of the boiling selenium.

This product was examined and appeared better than any previous sample. It was redistilled three times and the final product had practically no foreign material in it. The amount of the impurity present was so small that it in no way hindered the determination of the indices of refraction of high index materials.

Upon reexamination of the original selenium with the oil immersion objective whereby a magnification of at least 900 diameters was obtained, the particles larger than 1 or 2 microns in diameter were transparent and birefracting while only at lower magnifications did they appear opaque. This birefringence of the particles forms additional evidence that they are selenium dioxide since it likewise is birefracting. The opaque appearance at lower magnifications is probably due to the small size of the particles and the difference in index of refraction between them and the surrounding selenium.

Crystalline selenium also is birefracting, and it was thought at one time that the particles might be small crystals of selenium itself. However, when crystallization of selenium begins it spreads from a center; such spreading from the opaque particles was never evident. Furthermore crystallization in the film on slides only begins after a comparatively long time whereas the minute particles are always found in the selenium immediately after the slide has been made. In a film of purified selenium the particles were never found, as long as the film was heated just above the melting point. If they were the crystalline form of selenium they should not only occur in the unpurified material but in the purified samples as well.

Upon oxidation and reduction of some of the purified selenium there seemed to be as many of the opaque particles present as in the original samples. And when the purified selenium was distilled in air they reappeared also. In fact in any sample of optically clear selenium which was treated under any oxidizing conditions the particles were always found after such treatment.

Finally some crystals of selenium dioxide were intimately ground with purified selenium and a film of such a mixture was found to appear similar to a film of commercial selenium. The finer particles of the dioxide appeared opaque under low magnifications while only under the highest magnifications could any birefringence be detected.

All evidence, therefore, seems to indicate that selenium dioxide, SeO_2, is responsible for the apparently opaque particles which are found in commercial selenium.

SUMMARY

All selenium obtainable on the market, so far as examined, contains a trace of selenium dioxide. This dioxide appears under the microscope as small nearly opaque particles when the selenium is used as an index medium, and renders the material unsuited for such a purpose.

Several methods of purification have been attempted, and it has been found that the dioxide may be removed by distillation from a suitable container in an atmosphere of carbon dioxide. The distillate is then practically optically clear when melted into thin films such as are used in index determinations.

The author wishes to express his gratitude to Dr. R. H. Bogue for his advice and cooperation in outlining and directing this problem.

Further acknowledgement is due Dr. Herbert Insley for his interest in the work and his aid in the identification of the materials, and to Mr. F. W. Ashton for the preparation of the photomicrograph.

ELLSWORTHITE CRYSTALS FROM HALIBURTON COUNTY, ONTARIO[1]

H. V. Ellsworth, *Ottawa, Canada.*

Some months ago the writer received from Charles G. Earle of Haliburton, Ont., a few ounces of small, loose crystals which electroscope tests showed to possess considerable radioactivity, and which were immediately suspected of being either ellsworthite or betafite. The crystals received are free from gangue but are more or less coated with a yellowish brown decomposition or resorption product, as well as with small crystals of apatite, which along with calcite may also be included in part or completely within the crystals themselves. One fragment of a crystal, however, was entirely free from any superficial coating or alteration and showed clean, sharp, bright faces. The crystals vary from slightly less than $\frac{1}{4}$ inch to $\frac{1}{2}$ inch in diameter and in general exhibit a rounded octahedral habit, with the octahedron most prominent in combination with small cube faces and with rather frequent occurrence of small faces of the dodecahedron and the tetragonal trisoctahedron $m(311)$. Fig. 1. Owing to the rounding of edges and smaller faces, the octahedron and cube are sometimes the only definitely distinguishable forms. Several crystals however were in part sufficiently sharp and well developed to permit measurement and identification of the faces indicated in the figure. Other crystals are simply rounded, small ball-like masses on which the faces cannot be definitely identified.

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[1] Published by permission of the Director of the Geological Survey, Canada.

The color is black or brownish black, some crystals are darker than others; powder pale yellow; lustre adamantine; cleavage none, fracture subconchoidal to uneven; very brittle; hardness 4.5; specific gravity 3.705. Small grains under the microscope are brown and infusible.

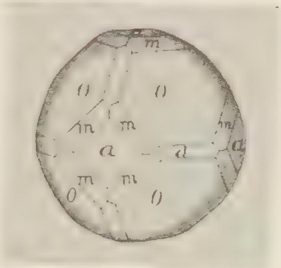

Fig. 1.
Typical crystal of ellsworthite. An attempt has been made to indicate the characteristic rounded outline.

One or two of the crystals were still embedded in calcite, the others apparently had weathered loose in a vug. Mr. Earle states that the crystals were obtained from lot 10, conc. 12, Cardiff township, Haliburton county, Ontario. The writer has not seen the actual occurrence but from information supplied by Mr. Earle and from notes obtained on a visit to that locality some years ago it is evident that the crystals occur in high temperature calcite veindikes[2] of igneous origin which are characteristic of that neighborhood. In the Haliburton-Bancroft area calcite is common as an apparently primary constituent of igneous rocks, occurring as small grains in the nephelite syenites and nephelite pegmatites and as larger masses, sometimes as much as 100 tons in weight, in the microcline-quartz pegmatites.[3] In the Harcourt-Wilberforce section of this area calcite is seen not only as a constituent of ordinary granite pegmatites but it also occurs as vein-like dikes up to 8 feet wide which have the same relation as the ordinary pegmatites to the enclosing rocks. The filling of these calcite dikes generally is chiefly white to pink calcite but sometimes there is almost as much fluorite as calcite, the two commonly forming crudely banded intergrowths. The fluorite when freshly mined shows a very dark purple color, sometimes almost black, but it fades completely in a year's time when exposed to the light. This same dark purple fluorite also occurs in small quantities in the microcline-quartz-calcite pegmatites at Hybla and in ordinary pegmatite elsewhere in Ontario and Quebec. For example, I have very recently found it occurring as an apparently primary constituent in a zirconiferous, pegmatitic granite mass exposed in a new railway cutting about ½ mile north of Kirks Ferry, Quebec. It seems that the dark purple color is characteristic for fluorite of igneous origin while that deposited by surface waters in true fissure veins, vugs, etc. is likely to be colorless to greenish. The dark purple color is quite likely due to exposure to the action of radioactive substances, as suggested by the experiments of Doelter.[4] Along with the calcite and fluorite are usually crystals of apatite and sometimes considerable masses of this mineral. The walls of the dikes are commonly lined with crystals of various pyroxenes, felspars—both potassic and sodic varieties—apatite, biotite, titanite, and sometimes a little allanite and zircon. The calcite dikes occur indifferently in granite or banded gneisses though they are never far from granite. In some cases they may be entirely enclosed in pegmatitic granite, in other cases they are at the contact of granite with banded gneiss. There is not the slightest doubt that they are just as much a product of the granitic intrusions of that region as are the microcline-quartz pegmatites themselves.

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[2] High temperature in contrast to ordinary fissure veins formed by circulating waters at or near ordinary temperatures, actually probably somewhere between 200° and 500°. The term veindike as proposed by Spurr seems very appropriate for this type of deposit representing the last residual material of a cooling magma.

To return to the radioactive crystals under discussion, it appears that they occur in a calcite veindike of the type just described and are thus closely related in mode of occurrence and origin to the ellsworthite found in the pegmatitic calcite masses of the MacDonald mine at Hybla. As the original ellsworthite of Hybla has never been found in crystals the new material was particularly interesting.

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[3] Ellsworth; Geol. Surv. Canada, Summary Report, Part CI, (1923).

[4] Das Radium und Die Farben.

The crystals selected for analysis were ground on a wet carborundum stone to remove any external coating, then crushed to small fragments and any foreign inclusions carefully picked out under the binocular. Finally the material was given a wash with dilute hydrochloric acid to remove any minute calcite grains or inclusions. It was then thoroughly washed and allowed to become perfectly dry in the air at room temperature before grinding. An analysis yielded the following results:

	PERCENT	MOL. WT.	BASES	ACIDS
PbO	1.73	222	0.0078	
($Pb=1.61$)				
UO_2	1.56	270.2	0.0058	
UO_3	20.46	286.2	0.0714	0.0714
$U=18.41=21.70\ U_3O_8$)				
ThO_2	0.10	264	0.0004	
(Th 0.09 x 0.38=0.03 U equivalent)				
$(Ce, La, Di)_2O_3$	1.49	330	0.0045	
$(Yt, Er)_2O_3$	0.12	230	0.0005	
FeO	0.22	72	0.0030	
Fe_2O_3	2.74	159.7	0.0171	
MnO	0.04	70.9		
Al_2O_3	0.12	102.2	0.0011	
BeO	0.02	25.1		
CaO	8.94	56	0.1596	
MgO	0.08	40.3	0.0020	
ZrO_2 not detected	0.00	122.6		
SnO_2	0.06	150.7		
TiO_2	15.06	80.1		0.1880
Cb_2O_5	23.44	266.2		0.0880
Ta_2O_5	9.97	443		0.0225
SiO_2	2.49	60.3		0.0413
P_2O_5	trace	UO_3 as base	0.2732	0.3398
F	▪	UO_3 as acid	0.2018	0.4112
H_2O 110–130°	4.59		0.6222	
H_2O 130+	6.61			
Insol.	0.21			
Ignition loss	11.54			
	100.05			

$$\frac{Pb}{U\ 0.38Th} = 0.094$$

Sp. Gr. = 3.705 at 18.93°

The analysis, unfortunately leaves one in some doubt as to whether this mineral is more closely related to ellsworthite or betafite. This uncertainty is not lessened by the fact that Lacroix appears to have included two minerals of quite different composition under the name betafite as shown in the three analyses (reproduced below) upon which he bases the species.

Analyses of Betafite by M. Pisani (A. Lacroix-Minéralogie de Madagascar, Tome I, p.384). A, from Ambolotara; B, from Ambalahazo; C, from Ambatolampikely.

	Per Cent A	Per Cent B	Per Cent C	Mol. Ratios A	Mol. Ratios B	Mol. Ratios C
PbO..........	—	—	—	—	—	—
UO_2..........	—	—	—	—	—	—
UO_3..........	26.60	27.15	28.60	.0929	.0948	.0999
ThO_2.........	1.30	1.12	1.25	.0049	.0042	.0047
$(Ce, La, Di)_2O_3$	0.60	1.00	1.20	.0018	.0030	.0036
$(Yt, Er)_2O_3$....	0.90	—	—	.0039	—	—
FeO..........	—	—	—	—	—	—
Fe_2O_3.........	2.87	0.50	1.38	.0180	.0031	.0086
MnO.........	—	—	0.25	—	—	.0035
Al_2O_3.........	2.10	1.50	0.50	.0205	.0147	.0049
BeO..........	—	—	—	—	—	—
CaO..........	3.45	3.12	11.61	.0616	.0557	.2073
MgO..........	0.40	trace	—	.0099	—	—
ZrO_2.........	—	—	—	—	—	—
SnO_2..........	0.30	0.37	—	.0019	.0025	—
TiO_2..........	18.30	16.20	17.30	.2285	.2022	.2160
Cb_2O_5.........	34.80	34.80	32.10	.1307	.1307	.1206
Ta_2O_5.........	trace	1.00	trace	—	.0023	—
SiO_2..........	—	—	—	—	—	—
K_2O..........	—	0.38	—	—	—	—
H_2O..........	7.60	12.50	5.20			
	99.22	99.64	99.39			
Sp. Gr.........	4.17	3.75	4.475			

		A	B	C
UO_3 as base	Acids	.3611	.3377	.3366
	Bases	.2135	.1795	.3325
UO_3 as acid	Acids	.4540	.4325	.4365
	Bases	.1206	.0847	.2326

It may be seen that analyses A and B agree very closely in CaO content and approximate molecular ratios while C is much higher in lime and has a very different ratio of acids to bases. C in fact is practically identical with ellsworthite as originally described by Walker and Parsons. Whether UO_3 is calculated as acid or base makes a great difference in the molecular ratios obtained. It is customary to consider UO_3 as an acid, forming uranates, but whether this is always true in the case of the complex titano-titantalo-columbate minerals is in the writer's opinion questionable. It seems probable that where the UO_3 was an original primary constituent of the mineral it should be considered as an acid, but that UO_3 resulting from autoxidation or normal oxidation of original UO_2 (which is a base) merely replaces the latter in the molecular network and should be calculated as a base. The difficulty is to distinguish the primary and secondary UO_3.

If it is agreed to consider the betafite is represented by analyses A & B and that C is ellsworthite, then the Haliburton mineral is probably more nearly related to ellsworthite with which it also agrees well in physical properties, mode of occurrence and origin.

The analyses of the original ellsworthite from Lot 18, Con. VII, Monteagle township, Hastings County, by E. W. Todd[5] are given for comparison.

	I (Lighter type)				II (Darker type)			
Nb_2O_3......	34.22		.125	.313	34.27		.125	.349
Ta_2O_5......	4.32		.009		4.27		.009	
TiO_2.......	10.47		.131		9.79		.122	
SnO_2.......	0.10		.001		0.25		.002	
SiO_2........	2.54		.042		2.68		.047	
F..........	0.22	(x½)	.005		0.49	(x½)	.013	
UO_2.......	....				8.42		.031	
UO_3........	18.50		.065	.326	10.68		.037	.321
CaO.......	11.73		.209		13.62		.243	
MnO......	0.43		.006		0.22		.003	
PbO.......	0.24		.001		0.41		.002	
Rare Earths	0.21		.001					
Fe_2O_3......	4.10	(x⅔)	.038		3.80	(x⅔)	.036	
Al_2O_3......	0.42	(x⅔)	.006					
H_2O........	12.22		.677÷2=.338		11.42		.634÷2=.317	
	99.72				100.32			
Sp. Gr......	3.608				3.758			

THE SERPENTINE LOCALITY OF MONTVILLE, NEW JERSEY

EARL V. SHANNON, *United States National Museum.*[1]

The name Montville, New Jersey, is familiar to all mineralogists and collectors throughout the world as the locality for the beautiful translucent oil-green serpentine which is to be found in most collections of consequence. Published descriptions of the place from which these specimens have come are very few indeed, almost the only one being Dr. George P. Merrill's[2] paper of many years ago. Although this paper gives an excellent description of the serpentine, its associations and probable origin, the article is now out of stock and not available to most persons who might be interested in visiting the locality.

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[5] Walker & Parsons: Contributions to Canadian Mineralogy, 1923, p. 14.

[1] Published by permission of the Secretary of the Smithsonian Institution.

Recently the writer spent about a month in Dover, N. J., in appraising and packing the Canfield collection of minerals. The opportunity of visiting a number of classic New Jersey mineral localities was thus offered and a Sunday was devoted to visiting the Montville locality in company with Geo. M. Hyland, Jr.

A description of the geography of the quarry is rather difficult. Montville is a small village on the Boonton branch of the Lackawanna Railroad about 2 miles northeast of Boonton. This is within the area of the Passaic quadrangle and the prospective visitor to the locality is strongly advised to provide himself in advance with a copy of the Passaic folio (folio 157, Geologic Atlas of the U. S., U. S. Geological Survey, Washington, D. C.). The quarry from which the specimens have come is indicated by the usual conventional sign in a small elongate area, designated in blue on the geologic map as Franklin limestone, about 3 miles NNE of Montville and on Turkey Mountain. If the folio is not available—it is out of stock at the Geological Survey—the folio should be consulted at a library, and the location of the quarry carefully copied on the Passaic topographic sheet which can be purchased.

The private road shown on the map as ascending the valley east of Turkey Mountain can be followed until it crosses the small tributary from the west which bisects the mountain. This valley, shown on the map as containing a small pond, has been dammed and is now occupied by an artificial lake of rare beauty about a mile long. After crossing the small stream mentioned, the writer simply ascended the nose of the ridge, disregarding a confusion of dim logging roads. The quarry was found precisely where indicated on the map but is badly overgrown and looks more like a natural ravine cutting into the ridge from the west than an artificial excavation. It probably has not been operated for thirty-five years. There seems to be no well marked road or path approaching it although there is a barely discernible and almost obliterated cart path up the ridge which probably furnished the outlet. The limestone was used for flux in iron furnaces or burned to quicklime. There are two ruined lime kilns alongside the road at the edge of the lake a mile below the quarry.

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[2] George P. Merrill. On the serpentine of Montville, New Jersey. *Proc. U. S. National Museum*, Vol. **11**, pp. 105–111 (1888).

Once found, the quarry yielded specimens of the serpentine in abundance. It is not necessary to repeat here Dr. Merrill's descriptions which indicate that the serpentine occurs as investing crusts of various thicknesses surrounding nodular masses of granular grayish diopside. He suggests that the serpentine is due to an alteration of the diopside and that its prevailing slickensided and grooved surfaces are due to volume increases resulting from such an alteration. The present writer does not dissent from any of Dr. Merrill's conclusions and can add but little of scientific consequence to his observations. Dr. Merrill mentions a small dike of dense trap rock, less than a foot in width, in the quarry opening which apparently had no connection with the serpentinization. This was not seen by the present writer. There was noted, however, in a wall of the quarry and intrusive into the monotonous Pre-Cambrian Losee Gneiss which incloses the limestone, an irregular dike of pegmatite of not unusual composition which may have furnished the thermal solutions which effected the transformation of the pyroxene to serpentine. Dr. Merrill quotes analyses which show the Montville serpentine to have some 2 per cent more water than ordinary serpentine and thus it is comparable to the variety retinalite which has been interpreted as a mixture of serpentine and deweylite. The finely fibrous metacolloidal structure of this serpentine as seen under the microscope, its excess water content, the abundance of shrinkage cracks which develop upon drying and its fine-grained colloidal appearance suggest that it was probably deposited originally in the amorphous form of deweylite.

The serpentine specimens available in the quarry vary from translucent light yellow-green to dark blackish-green. The gray granular pyroxene, thin veins of chrysotile, slickenside coatings of splintery picrolite, and flakes of coppery phlogopite in serpentine, diopside, and granular dolomite, constitute the list of minerals found here by the writer.

BOOK REVIEW

LEHRBUCH DER MINERALOGIE. II, SPEZIELLE MINERALOGIE

P. Niggli in collaboration with L. Weber. Large 8-vo., XVI+697 pages, with 330 figures. Gebrüder Borntraeger, *Berlin*, 1926. G. M. 30.

This is the second volume of Niggli's mineralogy which is undergoing a thorough revision. Volume one, devoted to general mineralogy, appeared in 1924 (*Am. Mineral.* **10**, 104, 1925).

Volume two is devoted entirely to special or systematic mineralogy. The presentation is interesting but extremely novel for, as is characteristic of Niggli's work, conventional methods and classifications are discarded. Crystal structure is made the basis of Niggli's classification, which of course means that minerals with strikingly different chemical compositions are brought together. Thus, in one section all minerals belonging to the cubic system or having a pseudo-cubical development are discussed. The morphological relationships, as well as other important physical, and chemical properties are stressed. Only brief reference is made to the formation and occurrence of minerals. Localities are generally omitted.

The volume contains a large amount of valuable data drawn from all possible sources without, however, citing the original contributions.

E. H. Kraus

NOTES AND NEWS

NOTE ON MINERALS FROM THE MAHOPAC MINE, PUTNAM COUNTY, NEW YORK

James H. C. Martens, *Cornell University*

Besides the minerals described by Gillson[1] the writer has collected from the dumps at the Mahopac Mine several additional minerals whose occurrence is here briefly mentioned.

Pyrrhotite is found abundantly on the mine dumps associated especially with mica but often occurring with the other silicates.

Chalcopyrite occurs with the pyrrhotite in small amounts.

Pyrite occurs rather sparingly and does not furnish any good specimens.

Calcite, coarsely crystalline, of pink to white color, with bent cleavage faces and polysynthetic twinning strongly developed was found containing good crystals of scapolite.

Dolomite. This is very coarse grained and is found with talc, chlorite, and other magnesium silicates. It contains enough iron so that it weathers brown.

Epidote of the common pistacite variety occurs in fine grained form with black hornblende; also in striated crystals up to a few centimeters in length embedded in calcite with scapolite and hornblende.

Talc occurs in masses of scaly crystals associated with dolomite and actinolite. Much of it has evidently been formed by the alteration of the latter mineral.

Titanite of the common brown variety occurs in small amounts in some of the blocks consisting principally of hornblende; also in small crystals of somewhat lighter color in veins of diorite pegmatite.

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[1] *Am. Mineral.*, **11**, (No. 10) pp. 281-286, October, 1926.

Dr. William D. Coolidge of the research laboratory of the General Electric Company has been awarded the Edison medal for 1926 by the Edison committee of the American Institute of Electrical Engineers "for the origination of ductile tungsten and the fundamental improvement of the X-ray tube."

Any member of The Mineralogical Society of America who desires a certificate of membership may secure same by writing to the secretary, Professor Frank R. Van Horn, Case School of Applied Science, Cleveland, Ohio.

A decennial index of The American Mineralogist covering volumes 1–10 will be prepared and offered for sale sometime during the current year. Orders can be placed with the Editor now as the size of the edition will be determined largely by the number of pre-publication orders. Information concerning the price of the index will be given at a later date.

Our stock of early issues of The American Mineralogist is badly depleted and as there is an increasing demand for complete sets of the Journal the Council of the Society has authorized funds to provide for the reproduction of the issues of 1916–1920 by a new photographic process. Members and subscribers to the Journal who in the past have been unable to secure complete sets, or fill out their broken files, will be able to purchase the necessary numbers as soon as the new stock becomes available.

A news dispatch in the press a short time ago stated that the "great ruby of Russia," for many years considered one of the most valuable of Russian crown jewels, has been declared by Professor A. E. Fersman to be rubellite from Burma.

A note in *Industrial and Engineering Chemistry* calls attention to a large deposit of cyanite at Burnsville, North Carolina, near the Tennessee border. The minerals associated with cyanite include feldspar and mica. The deposit is owned by the Pollard Clay Co., of Burnsville, who propose to work the deposit.

Dr. Edgar T. Wherry of the Bureau of Chemistry, Department of Agriculture, Washington, D. C., has been elected president of the Washington branch of the American Chemical Society.

As a result of core drilling in the southeastern corner of New Mexico ten beds of potash minerals (polyhalite, sylvite, etc.) aggregating nearly thirty feet in thickness were discovered at depths ranging from 790 ft. to 1760 ft. The potash minerals showed a K_2O content as high as 18.5%. (The average run-of-mine minerals of the Stassfurt beds have a potash content of 8–10 per cent). At a depth of about 1430 ft. a seventeen inch bed of langbeinite was found. Other core drillings are necessary to determine the extent of these potash deposits.

Potash deposits have also been found in Russia, in the district of Solikamsk, government of Perm. The Russian deposits are found over an area almost 1000 sq. mi. in extent and at a depth of only 300 ft. from the surface.

A new magazine known as *Rocks and Minerals* has recently been started by Peter Zodac, 157 Wells Street, Peekskill, New York. It is to appear quarterly and according to the editor will be devoted "chiefly to rocks, minerals, ores, crystals and gems, in the interest of the general collecting public." We extend to Mr. Zodac our best wishes for success in his new venture.

PROCEEDINGS OF SOCIETIES

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences of Philadelphia, Dec. 2, 1926

A stated meeting of the Philadelphia Mineralogical Society was held on the above date, the president, Mr. Vaux, presiding. Twenty-five members and five visitors were present.

Mr. Frederick Richter was elected to membership. Dr. Paul F. Kerr of Columbia University addressed the society on "*X-ray crystal methods applied to mineral study.*" The three methods used for the study of minerals with X-rays were described. The Laue and the Braggs' methods for photographing X-rays reflected from crystal or cleavage surfaces are of limited application since both of these methods require the presence of rather large crystal or cleavage faces in the mineral under investigation. The photographic record of the diffraction pattern obtained when X-rays are passed through powdered minerals gives promise of wide use. A diffraction pattern may be obtained from as little as 50 mg. of some minerals.

The speaker explained the way X-ray photographs are taken and the manner of measuring and interpreting the patterns. The talk was illustrated by means of numerous lantern slides showing the apparatus used for X-ray investigations of minerals and the patterns obtained from a number of minerals.

Specimens of prehnite, pectolite and other minerals from Paterson, N. J. were exhibited by Mr. Biernbaum.

F. A. CAJORI, *Secretary*

NEW MINERAL NAMES

Salmoite

E. S. LARSEN: Microscopic determination of the nonopaque minerals. *U. S. Geol. Surv. Bull.* **678**, p. 135 (1921).

NAME: From the locality, *Salmo*, British Columbia.

CHEMICAL PROPERTIES: Presumably a basic zinc phosphate.

OPTICAL PROPERTIES. Optically—; 2 V moderately large; $\rho > v$ (perceptible); $\alpha = 1.645$, $\beta = 1.683$, $\gamma = 1.695$; (all $\pm$ 0.003). Colorless.

OCCURRENCE. With spencerite and hibbenite at the Hudson Bay Mine, Salmo, British Columbia.

DISCUSSION. Salmoite is presumably the "new basic zinc phosphate" mentioned by A. H. Phillips, *Am.J.Sc.*, 42, 278(1916). No evidence as to the chemical composition of the material described optically by E. S. Larsen is given.

J. F. SCHAIRER.

Yuksporite

A. E. FERSMAN. *C. R. Acad. Sc. Russie*, p.60,(1922); *Trans. Northern Sc. Econ. Exped.*, No. 16, pp. 16, 52, 68, 73, (1923).

NAME. From the locality, *Yuksporlack* in the Kola peninsula.

CHEMICAL PROPERTIES: Analysis SiO_2 40.92, Fe_2O_3 9.10, MnO 0.91, CaO 20.56, MgO 0.42, Na_2O 7.94, K_2O 12.57, H_2O 8.52; sum 100.94. Referred by Fersman to the pectolite group.

PHYSICAL PROPERTIES: Color rose-red, fibrous and lamellar.

OCCURRENCE: With titanite, pectolite, astrophyllite, biotite and aegirite in veins in nephelite-seynite.

DISCUSSION: Optical data and proof of homogeneity are needed. It seems to be the same as natroxonotlite (J. F. Williams, *Ann. Rept. Geol. Surv. Ark.*, 2, 355 et seq. 1891).

J. F. S.